Spatial Digital Database of Selected Data from the Geologic Map of the Western Part of the Cut Bank 1° x 2° Quadrangle, Northwestern Montana

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Geologic Investigations Series Map I-2593
Digital database, version 1.0

Prepared in cooperation with the Montana Bureau of Mines and Geology

2002
(map originally published in 1998)

Manuscript approved for publication January 2, 2002

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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Table of Contents

List of Figures

Introduction

The paper geologic map of the western part of the Cut Bank 1° x 2° quadrangle, northwestern Montana 1:250,000 (Harrison and others, 1998) was digitized and initially attributed by the Montana Bureau of Mines and Geology (MBMG) before remitting to the U.S. Geological Survey for further attribution and publication of the geospatial digital files. The resulting digital geologic map GIS can be queried in many ways to produce a variety of geologic maps. This digital geospatial database is one of many being created by the U.S. Geological Survey as an ongoing effort to provide geologic information in a geographic information system (GIS) for use in spatial analysis. Digital base map data files (topography, roads, towns, rivers and lakes, etc.) are not included, however they may be obtained from a variety of commercial and government sources. This digital map is only consistent with the 1:250,000-scale topographic base maps and should not be used at larger scales (for example, 1:100,000 or 1:24,000). The digital geologic map graphics and plot files (cb250k.gra/.hp /.eps) that are provided in the digital package are representations of the digital database.

The map area is located in western Montana (fig. 1). This report describes the geologic map units, the methods used to convert the geologic map data into a digital format, the ArcInfo GIS file structures and relationships, and explains how to download the digital files from the U.S. Geological Survey public access World Wide Web site on the Internet.

We wish to thank Lorre Moyer of the U.S. Geological Survey for reviewing the manuscript and digital files.

Description of Map Units

Harrison and others' (1998) description of map units is provided below as a courtesy to the reader.

Qal Alluvial deposits (Holocene)—Gravel, sand, silt, and clay in flood plains and low terraces along present drainages. Includes alluvial fans.

Qs Landslide deposits (Holocene and Pleistocene)—Includes large rock slumps, flow, and slides. Generally consists of angular blocks of bedrock in a finer grained matrix; mixed at places with glacial debris. Most abundant on slopes topographically below trace of Lewis thrust fault on east and south sides of Glacier National Park (Carrara, 1990).

Qg Glacial and fluvioglacial deposits (Pleistocene)—Includes till (in ground, end, and ablation moraines), outwash, and other fluvioglacial deposits from both continental and mountain glaciers. Includes eskers at a few places in Glacier National Park (Carrara, 1990).

Tk Kishenehn Formation (Oligocene and Eocene)—Conglomerate, sandstone,

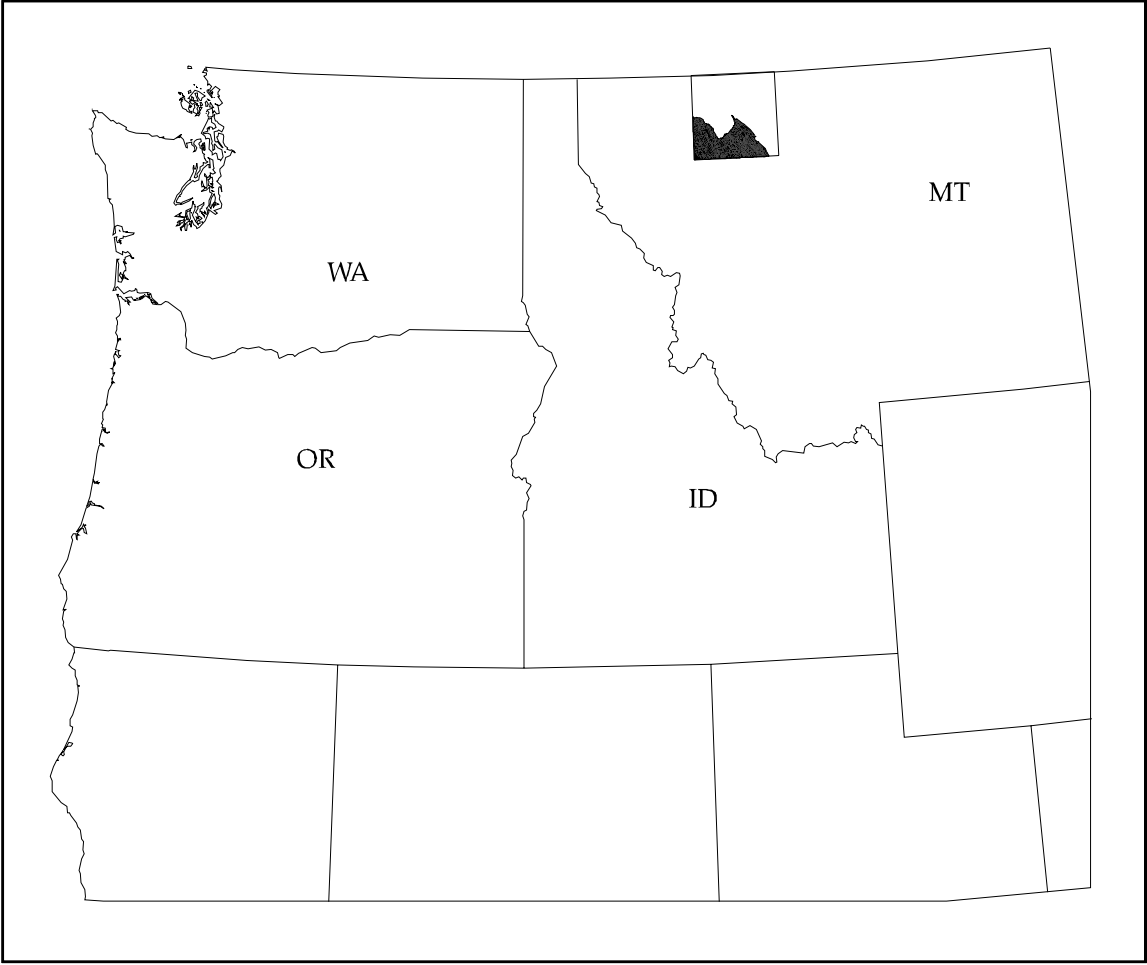

Figure 1. Index map showing the geographic extent of the map area (black fill and small square outline) with respect to the Pacific Northwest.

siltstone, marlstone, oil shale, and coal deposited in the Kishenehn basin. About 3,800 ft thick in the valley of the Middle Fork of the Flathead River in central part of map area (Whipple, 1992).

Ku Upper Cretaceous rocks, undivided—Mainly dark-gray mudstone of the Marias River Shale as described by Mudge and Earhart (1983). May include the Horsethief Sandstone and St. Mary River Formation at northeast edge of Glacier National Park. At least 1,500 ft thick.

Kl Lower Cretaceous rocks, undivided—Predominantly gray to olive mudstone and gray sandstone interbedded with some limestone. Includes the Blackleaf, Kootenai, and Mount Pablo Formations as mapped and described by Mudge and Earhart (1983). Thickness about 2,200 ft.

KJu Mount Pablo Formation (Lower Cretaceous), Morrison Formation (Upper Jurassic), and Ellis Group (Upper and Middle Jurassic), undivided—Includes siltstone, sandstone, and shale accompanied by minor limestone and thin conglomerate at base of some members as mapped and described by Mudge and Earhart (1983). About 1,500 ft thick.

Mm Madison Group (Upper and Lower Mississippian)—Upper part is the Castle Reef Dolomite and lower part is the Allan Mountain Limestone as mapped and described by Mudge and Earhart (1983). About 1,200 ft thick.

Du Three Forks (Upper Devonian), Jefferson (Upper Devonian), and Maywood (Upper and Middle Devonian) Formations, undivided—Mainly limestone and dolomite in upper part; in lower part mudstone increases downward. Units mapped and described by Mudge and Earhart (1983). About 1,700 ft thick.

Cu Upper and Middle Cambrian rocks, undivided—Alternating units of carbonate and shale above a basal sandstone. In Montana disturbed belt, includes (in descending order): Devils Glen Dolomite (Upper Cambrian), Switchback Shale (Upper and Middle Cambrian), and Steamboat Limestone, Pentagon Shale, Pagoda Limestone, Dearborn Limestone, Damnation Limestone, Gordon Shale, and Flathead Sandstone (Middle Cambrian) (Mudge and Earhart. 1983). Only lower three or four formations exposed unconformably above Belt rocks in southern part of map area. Maximum exposed thickness about 1,000 ft.

ZYd Mafic sills and dikes (Late and Middle Proterozoic)—Dioritic to gabbroic rocks that commonly show alteration of mafic minerals to calcite, epidote, clinozosite, and hematite or limonite. Sills range in thickness from a few tens to a few hundreds of feet. Thicker sills tend to have contact-metamorphic zones around them. Sills commonly persist for many miles and in most places maintain

approximately the same stratigraphic position. Locally, they cut across the section at a low angle or, rarely, cut steeply across section to form dikes. Intruded in map area probably at about 1,000 Ma, or 800 Ma, or both (Harrison, 1972).

Ygr Garnet Range Formation (Middle Proterozoic)—Gray to olive, micaceous siltite to quartzarenite interlaminated or interbedded with gray-green, micaceous, argillitic siltite. Occurs only in small exposures at south edge of map area beneath Cambrian unconformity. Maximum thickness of remnant about 500 ft.

Ym McNamara Formation (Middle Proterozoic)—Predominantly grayish-green, interbedded and interlaminated argillite and siltite that contain thin chert laminae and chips. Oolites, stromatolites, quartzarenite, and stratabound cooper [sic] minerals present at places. Relatively thin red-bed sequences locally interbedded in the green strata. Small-scale sedimentary features include ripple marks, shrinkage cracks, scours, and crossbeds. Rests sharply on Bonner Quartzite. About 4,000 ft thick.

Ybo Bonner Quartzite (Middle Proterozoic)—Red to pink, micaceous, arkosic, crossbedded, fine- to medium-grained quartzite containing red argillite interclasts. Tabular and trough crossbeds and climbing ripple marks common. Interbeds of red, laminated argillite and pink, planar-laminated siltite scattered throughout unit. Rests in sharp contact on Mount Shields Formation. Thickness ranges from about 800 to 1,200 ft.

Yms Mount Shields Formation (Middle Proterozoic)—Consists of a series of informal members similar to those seen to the west in the Kalispell 1°x2° quadrangle (Harrison and others, 1992) where six informal members are described; sequence in the Cut Bank quadrangle is similar, but member 5 is missing. Type section (Childers, 1963), about 2,550 ft thick, is between the Blacktail and Roosevelt faults in southeast corner of Glacier National Park on Mount Shields. Childers did not use the informal members subsequently found to be widespread in the formation. Maximum thickness in map area about 2,900 ft.

Uppermost unit in map area (member 6) is a thinly laminated, black argillite and white or green siltite that commonly displays small-scale slump folds and shrinkage cracks. Thickness about 200 ft. Conformably below is member 4, which consists of blocky, green, dolomitic, silty argillite that shows parallel-laminated graded couplets. Foot-thick carbonate beds are scattered throughout unit, as are rare salt casts. Thickness about 900 ft. Grades downward into member 3, which is predominantly alternating red and green beds of interlaminated argillite and siltite. Mud chips, mud cracks, ripple marks, and fluid-escape structures are common. Salt casts are abundant, particularly in red beds. Thickness about 500 ft. Grades by interlayering, through a few tens of feet, to member 2 below. Member 2 is pale-red, flat-laminated, coarse-grained siltite

to fine-grained quartzarenite that is blocky, feldspathic, and dolomitic. Dolomite is in cement or in streaks and pods parallel to bedding. Minor layers of red or green argillite. Red or buff stromatolites and oolites in a zone of one or more beds at top. Thickness about 700 ft. Grades downward into member 1. Member 1 is red to maroon, feldspathic quartzarenite interbedded with red siltite. Siltite increases in abundance to east and north. Red argillite beds and partings common between coarser grained beds. Cross stratification, mud chips, and heavy-mineral streaks common. Rare stromatolites. Thickness about 600 ft in southern part of map area.

Ysh Shepard Formation (Middle Proterozoic)—Consists of a variety of rock types, most of which are carbonate bearing or carbonate rich. The most characteristic lithology is green to gray, dolomitic argillite and siltite in even-parallel to wavy laminae that show graded couplets. This rock weathers into distinctive orange-brown platy slabs. Common interbeds a few to a few tens of feet thick include gray dolomitic limestone, stromatolites and oolites, laminated green argillite, gray argillitic siltite, and white quartzarenite. All rock types may contain pyrite cubes, small-scale wiggly calcite segregations (molar tooth structure), horizontal carbonate pods, ripple marks, or mud cracks. Base of unit is marked at places by shallow channels of quartzarenite, or in northwestern part of map area by an unconformity that separates the Shepard from the underlying Purcell Lava. Shepard thickness ranges from about 700 ft in Glacier National Park to about 2,700 ft in the Swan Range in southwestern part of map area.

Ysn Snowslip Formation (Middle Proterozoic)—Type section of the Snowslip Formation (Childers, 1963) is on the south spur of Mount Shields in the southern part of Glacier National Park. Detailed study of the Snowslip by Whipple and Johnson (1988) in the park has led to recognition of six informal members that can be correlated over at least the 1,000 mi^2 of the park. The Snowslip generally consists of two alternating intervals that are each one hundred to several hundred feet thick. One interval consists of thinly laminated, red to purple argillite and siltite interbedded with thinly laminated green argillite and siltite. The other interval consists of couplets of greenish-gray siltite and olive argillite. Within both intervals are beds of stromatolites, arenite, and carbonate as layers or cement; certain characteristics of these carbonate and arenite interbeds help to distinguish the various members of the Snowslip (Whipple and Johnson, 1988). Small-scale sedimentary structures include mud cracks, ripple marks, mud-chip breccias, fluid-escape structures, cross lamination (particularly in the arenite beds), and flat-pebble conglomerate. Sharply overlies Helena Formation. The Snowslip and its members generally thin to the north and thicken to the west across depositional strike. Ranges in thickness from about 1,200 ft in the north to about 4,000 ft in the Swan Range to the south.

Yh Helena Formation (Middle Proterozoic)—The most carbonate-rich formation in

the Belt Supergroup. Contains abundant beds of dolomite, stromatolitic or oolitic limestone, and molar-tooth limestone and dolomite, and lesser amounts of quartzarenite and black argillite. In Glacier National Park contains an interval of stromatolitic limestone about 100 ft thick (the conophyton zone of Rezak, 1957) that separates the upper and middle parts of the Helena. Commonly displays sedimentary cycles, 6-50 ft thick, that in eastern exposures have a clastic bed at the base, stromatolitic and oolitic beds in the middle, and dolomite at the top (Eby, 1977). Abundance of stromatolites and oolites decreases rapidly to the west and south where cycles are still well defined but change to a clastic bed at the base, a middle unit of silty dolomite containing pods and ribbons of calcite, and an upper unit of dense, chonchoidal-fracturing dolomite. Rests on laminated green argillite beds of the Empire Formation. Formation changes thickness rapidly across the various structural blocks in the map area, ranging from about 1,200 ft in southeastern Glacier National Park to about 7,000 ft in the Swan Range.

Ye Empire Formation (Middle Proterozoic)—Thinly laminated, dark-green and light-green dolomitic argillite and silty argillite or siltite. Laminae mostly wavy and discontinuous although some are even parallel. Fluid-escape structures are characteristic, and horizontal pods of white or pink calcite are particularly abundant in upper part. Ripple marks, syneresis cracks, and mud chips common in places. Lower part contains white dolomitic quartzarenite beds as thick as 10 ft. Pyrite cubes common in more carbonate-rich strata, and a few exposures display stratabound copper minerals. A few purple interlaminated argillite and siltite beds commonly occur near base and at places near middle of unit. Thickness about 500 ft.

Ys Spokane Formation (Middle Proterozoic)—Three lithologic units are found in most areas. The upper member has beds a few feet to a few tens of feet thick of laminated, green argillite and siltite that alternate with much thicker beds of purple, laminated argillite and siltite. Dolomitic cement is common as are ripple marks, mud chips, desiccation cracks, fluid-escape structures, ball-and-pillow structures, and flute casts. Beds a few inches to a few feet thick of white, rounded grains forming medium-grained, crossbedded quartzite that displays mud chips and balls on cross strata are abundant in northern part of map area but decrease rapidly in both number and thickness in southern and western parts. The middle member is predominantly pink to purple-gray, very fine grained, feldspathic quartzite or coarse siltite that has planar lamination or long tabular cross lamination. Interbeds of purple argillite are common. The lower member is similar to the upper member but has more purple argillitic beds, is more dolomitic, and has scattered iron-carbonate specks and cement. The Spokane changes facies eastward and northward where abundance of distinctive white, rounded-grain quartzite has been used arbitrarily to define the laterally equivalent Grinnell Formation. Maximum

thickness of the Spokane is about 4,500 ft in the Swan Range, but the unit thins to about 1,700 ft in northern exposures.

Ygl Grinnell Formation (Middle Proterozoic)—Term used in Glacier National Park for the quartzarenite-rich lithofacies equivalent to the Spokane Formation. White, rounded-grain, crossbedded quartzarenite containing red argillite chips and pellets forms about 60 percent of the formation and almost 100 percent of the upper part. Amount of quartzarenite decreases rapidly westward and southward. Red to purple laminated siltite, silty argillite, and argillite form interbeds that make up most of the remainder of the unit. Argillitic beds generally have even-parallel lamination, and couplets of argillite and siltite display ripple marks, mud cracks, and fluid-escape structures. Grades by interlayering into the Appekunny Formation. Thickness ranges from about 1,700 to 2,600 ft.

Yap Appekunny Formation (Middle Proterozoic)—Predominantly bright-green to olive argillite interbedded and interlaminated with laminated olive siltite and gray pyritic quartzarenite that weathers brown. Lower part contains maroon argillite and siltite. Can be divided into five informal members in Glacier National Park (Whipple, 1992). Various members' display mud cracks, mud-chip breccia, load structures, fluid-escape structures, and a few scour-and-fill structures. Rests unconformably on Altyn Formation in Glacier National Park but apparently intertongues with Prichard Formation transition member to southwest where unit mapped as Appekunny along west side of Flathead Range has beds characteristic of both Appekunny and Prichard. Maximum thickness about 2,000 ft.

Prichard Formation (Middle Proterozoic)

Ypt Transition member—Generally consists of three units: a basal unit of medium-gray blocky-weathering siltite and minor quartzite, a middle unit of interlaminated light- and dark-gray siltite and argillite, and an upper unit similar to the middle but containing interbeds of light-olive-gray siltite and quartzite similar to those in the overlying Appekunny Formation. These three units are present nearly everywhere, but their relative proportions vary from place to place. Laminae are wavy to lenticular; scour-and-fill structures, fluid-escape structures, and syneresis cracks are common. Iron sulfide weathers to give rusty aspect to many outcrops. Randomly oriented biotite porphyroblasts common, particularly near top, in all but easternmost exposures. Calcareous siltite and argillite beds, some in the middle but most in the upper unit, make up a small part of the member. Contains some stromatolitic beds in Glacier National Park. Probably intertongues with Altyn Formation to east. Basal contact is sharp. Thickness about 2,000 ft.

Data Sources, Processing, and Accuracy

The Harrison and others' (1998) map of the western part of the Cut Bank 1° x 2° quadrangle was digitized and minimally attributed by Ken Sandau (Montana Bureau of Mines and Geology) under contract with the U.S. Geological Survey. Robert J. Miller (U.S. Geological Survey, Menlo Park, CA) combined the faults file into the contact and rock unit file. Then Helen Kayser (Information Systems Support, Inc., Spokane, WA) augmented the file with an interim geologic map data model (data base), further attributed and edited, and then plotted and compared to the original stable-base geologic map to check for digitizing and attributing errors. All processing by the U.S. Geological Survey was done in ArcInfo version 8.1 (installed on a Sun Ultra workstation).

The overall accuracy (with respect to the location of polygons) of the digital geologic map (see figs. 2 and 3 for page-size versions) is probably no better than +/127 meters. This digital database is not meant to be used or displayed at any scale larger than 1:250,000 (for example, 1:100,000 or 1:24,000).

LIST OF MAP UNITS

Figure 2. Explanation for the Simplified Digital Geologic Map of the Western Part of the Cut Bank 1:250,000 Quadrangle

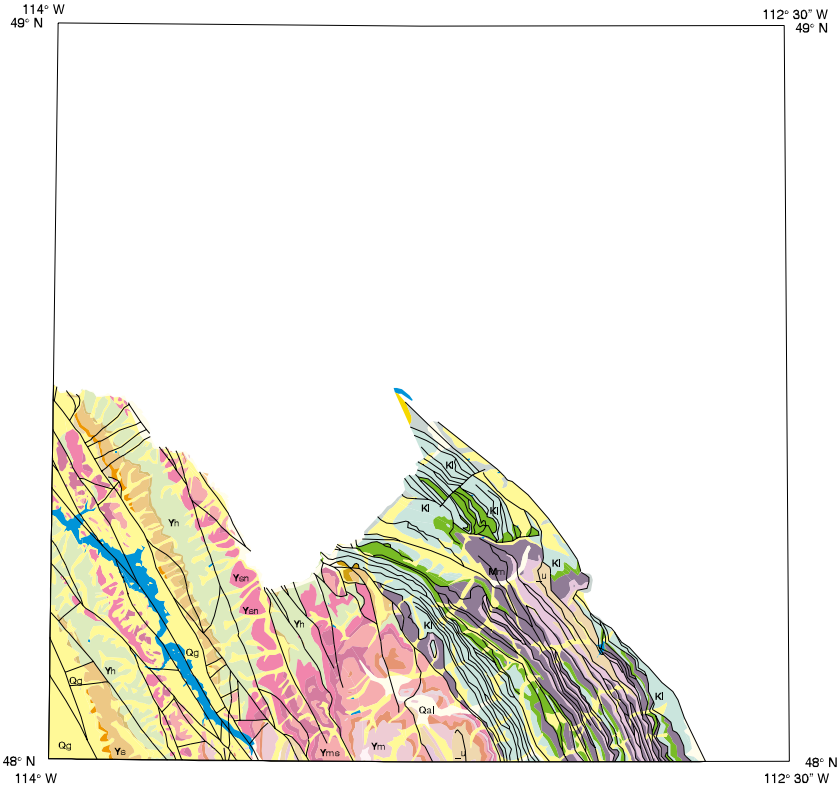

Figure 3. Simplified Digital Geologic Map of the Western Part of the Cut Bank 1:250,000 Quadrangle

GIS Documentation

The digital geologic map of the western part of the Cut Bank 1° x 2° quadrangle, northwestern Montana includes a geologic linework arc attribute table, CB250K.AAT, that relates to the CB250K.CON, CB250K.ST2, and CB250K.REF files and a rock unit polygon attribute table, CB250K.PAT that relates to the CB250K.RU and CB250K.REF files (see fig. 4). These data files are described below.

Linear Features

Descriptions of the items identifying linear features such as boundaries (for example, lines of latitude and longitude, state boundaries) and geologic boundaries in the arc (or line) attribute table, CB250K.AAT, are as follows:

CB250K.AAT			
ITEM NAME	ITEM TYPE	ITEM LENGTH	ATTRIBUTE DESCRIPTION
linecode	integer	4	Numeric code used to identify type of linear feature. Linecodes < 100 represent contacts and boundaries that are described in the CB250K.CON file. Linecodes > 100 and < 600 represent structural features which are described in the CB250K.ST2 file.
name	character	30	Name given to structural feature
source	integer	4	Numeric code used to identify the data source for the linear feature. Complete references for the sources are listed in the CB250K.REF file.)

Attribute descriptions for items in the contact (and boundary) look-table, CB250K.CON [for use with the GEOL_DIA.LIN lineset], are as follows:

CB250K.CON			
ITEM NAME	ITEM TYPE	ITEM LENGTH	ATTRIBUTE DESCRIPTION
linecode	integer	3	Numeric code (a value < 100) used to identify type of contact or boundary. (This item also occurs in CB250K.AAT.)
symbol	integer	3	Line symbol number used by ArcInfo to plot lines. Symbol numbers refer to the **GEOL_DIA.LIN** lineset for linecodes gt 0 and lt 100.
type	character	10	Major type of line, for example, contact, state boundaries, lines of latitude and longitude used for neatlines.
modifier	character	20	Line type modifier, for example, approximate, concealed, gradational. No entry implies 'known.'
certainty	character	15	Degree of certainty of contact or boundary, for example, inferred, uncertain. No entry implies 'certain.'
desc	character	100	Written description or explanation of contact or boundary.

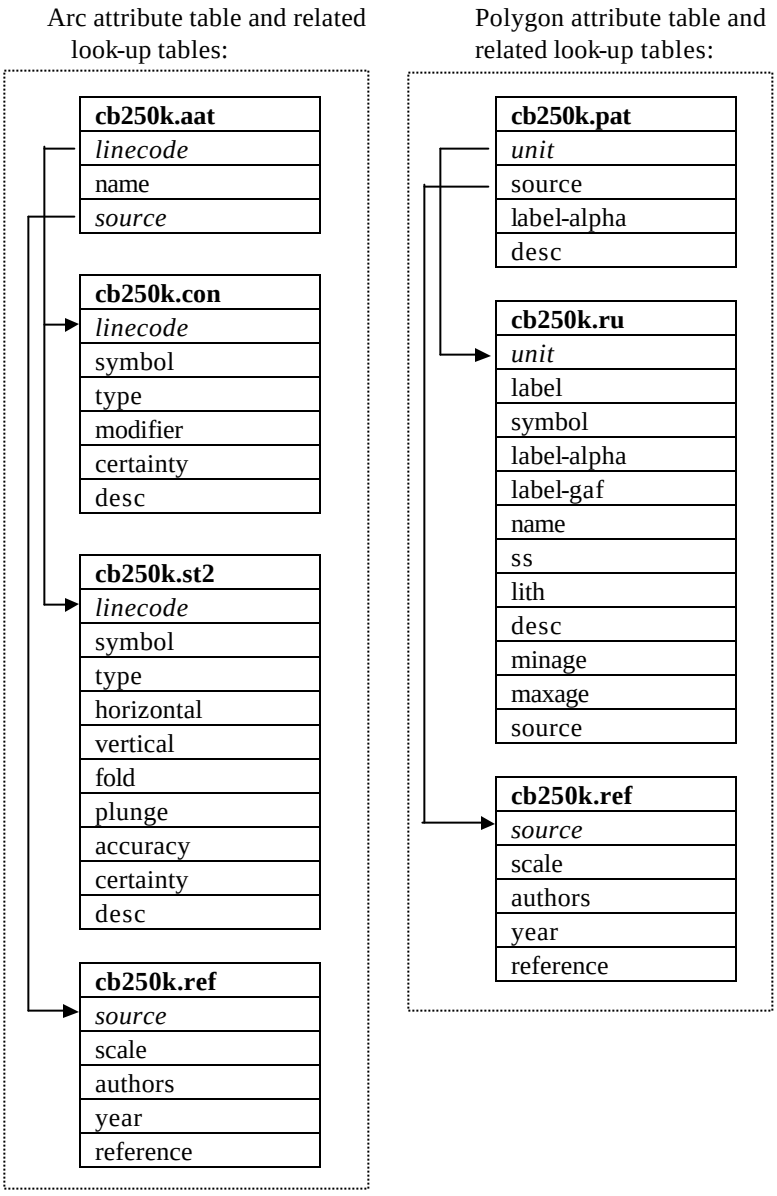

Figure 4. Relationships between feature attribute tables and look-up tables

Attribute descriptions for items in the structure look-up table, CB250K.ST2 [for use with the GEOL_DIA.LIN lineset] are as follows:

CB250K.ST2			
ITEM NAME	ITEM TYPE	ITEM LENGTH	ATTRIBUTE DESCRIPTION
linecode	integer	3	Numeric code (a value > 100 and < 600) used to identify type of structural feature. (This item also occurs in CB250K.AAT.)
symbol	integer	3	Line symbol number used by ArcInfo to plot arc (line). Symbol numbers refer to the **GEOL_DIA.LIN** lineset
type	character	10	Major type of structure, for example, fault, fracture, fold, other.
horizontal	character	20	Type of horizontal fault movement, for example, left-lateral, right-lateral. No entry implies 'unknown.'
vertical	character	20	Type of vertical fault movement, for example, normal. No entry implies 'unknown.'
fold	character	15	Type of fold, for example, anticline, syncline.
plunge	character	15	Type of plunge on fold, for example, horizontal, plunging, plunging in, plunging out.
accuracy	character	15	Line type modifier indicating degree of accuracy, for example, approximately located, concealed, gradational. No entry implies 'known.'
certainty	character	15	Degree of certainty of contact or boundary, for example, inferred, uncertain. No entry implies 'certain.'
desc	character	100	Written description or explanation of structural feature.

Areal Features

Descriptions of the items identifying geologic units in the polygon attribute table, CB250K.PAT, are as follows:

CB250K.PAT			
ITEM NAME	ITEM TYPE	ITEM LENGTH	ATTRIBUTE DESCRIPTION
unit	integer	4	Numeric code used to identify the rock unit which is described in the CB250K.RU look-up table. (This item also occurs in CB250K.RU.)
source	integer	4	Numeric code used to identify the data source for the rock unit. Complete references for the sources are listed in the CB250K.REF file.
label-alpha	character	10	Rock unit label (abbreviation) used to label unit on map. (This item was joined from the CB250K.RU look-up table.)
desc	character	250	Formal or informal unit name. (This item was joined from the CB250K.RU look-up table.)

Attribute descriptions for items in the lithology (rock unit) look-table, CB250K.RU (for use with the WPGCMYK.SHD shadeset), are as follows:

CB250K.RU			
ITEM NAME	ITEM TYPE	ITEM LENGTH	ATTRIBUTE DESCRIPTION
unit	integer	4	Numeric code used to identify rock unit. (This item also occurs in CB250K.PAT.)
label	character	10	Rock unit label (abbreviation) used to label unit on map.
symbol	integer	3	Shadeset symbol number used by ArcInfo to plot a filled/shaded polygon. The symbol numbers used in this file refer to the **WPGCMYK.SHD** shadeset.
label-alpha	character	10	Rock unit label for use with standard alphabetic characters (for example, C for Cambrian).
label-gaf	character	10	Rock unit label for use with GeoAge Font (geofont.txt) to produce geologic age characters (for example, € for Cambrian)
name	character	7	The prefix portion of the rock unit label that does not include subscripts. (If subscripting is not used in the original unit label, then the 'name' entry is the same as the 'label' entry.)
ss	character	3	The suffix portion of the geologic unit label that includes subscripts.
lith	character	20	Major type of lithostratigraphic unit, for example, unconsolidated sediments, sedimentary rocks, metasedimentary rocks, intrusive rocks, extrusive rocks, metamorphic rocks, water, ice.
desc	character	250	Formal or informal unit name
minage	character	7	Minimum stratigraphic age of lithologic unit, for example, CRET, TERT, PCY.
maxage	character	7	Maximum stratigraphic age of lithologic unit
source	character	4	Numeric code used to identify the data source for the rock unit. Complete references for the sources are listed in the CB250K.REF file.

Source Attributes

Descriptive source or reference information for the CB250K ArcInfo datasets is stored in the CB250K.REF file. Attribute descriptions for items in the CB250K.REF data source file are as follows:

CB250K.REF			
ITEM NAME	ITEM TYPE	ITEM LENGTH	ATTRIBUTE DESCRIPTION
source	integer	4	Numeric code used to identify the data source. (This item also occurs in the CB250K.AAT, CB250K.PAT, and CB250K.RU files.)
scale	integer	8	Scale of source map. (This value is the denominator of the proportional fraction that identifies the scale of the map that was digitized or scanned to produce the digital map.)
authors	character	200	Author(s) or compiler(s) of source map entered as last name, first name or initial, and middle initial.
year	integer	4	Source (map) publication date
reference	character	250	Remainder of reference in USGS reference format.

Obtaining Digital Data

The complete digital version of the geologic map is available in ArcInfo interchange- format with associated data files. These data and map images are maintained in a Transverse map projection:

Projection:	Transverse_Mercator
Units:	meters
Datum:	NAD27
Spheroid:	Clarke1866
Parameters:	
Scale factor at central meridian	1.000000
Longitude of central meridian	–113 0 0
Latitude of projections origin	0 0 0.00
False easting (meters)	0.00
False northing (meters)	0.00

To obtain copies of the digital data, do one of the following:

1. Download the digital files from the USGS public access World Wide Web site on the Internet: **URL =** http://geopubs.wr.usgs.gov/i-map/i2593/

or

2. Anonymous FTP from **geopubs.wr.usgs.gov,** in the directory
   pub/i-map/i2593/

The Internet sites contain the digital geologic map of the western part of the Cut Bank 1° x 2° quadrangle both in ArcInfo interchange-format files (cb250k.e00) and as HPGL2, encapsulated PostScript, and portable document format plot files (cb250k.hp, cb250k.eps, cb-map.pdf) of the map area, as well as the associated data files and ArcInfo macro programs which are used to plot the map at a scale of 1:250,000.

To manipulate this data in a geographic information system (GIS), you must have a GIS that is capable of reading ArcInfo interchange-format files.

Obtaining Paper Maps

Paper copies of the digital geologic maps are not available from the U.S. Geological Survey. However, with access to the Internet and access to a large-format color plotter that can interpret HPGL2 (Hewlett-Packard Graphics Language) or PDF (portable document) files, a 1:250,000-scale paper copy of the map can be made, as follows:

1. Download the digital version of the maps, **cb250k.hp, cb250k.eps, or cb-map.pdf,** from the USGS public access World Wide Web site on the Internet using the
URL = http://geopubs.wr.usgs.gov/i-map/i2593/
or
2. Anonymous FTP the plot files, **cb250k.hp, cb250k.eps, and/or cb-map.pdf** from: **geopubs.wr.usgs.gov,** in the directory:
pub/i-map/i2593/

3. These files can be plotted by any large-format color plotter that can interpret HPGL2, encapsulated Postscript, or Adobe Acrobat files. The finished plot is about 28 inches by 28 inches.

Paper copies of the map can also be created by obtaining the cb250k.aml file and then creating a plot file in ArcInfo.

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Mudge, M.R., and Earhart, R.L., 1983, Bedrock geologic map of part of the northern disturbed belt, Lewis and Clark, Teton, Pondera, Glacier, Flathead, Cascade, and Powell Counties, Montana: U.S. Geological Survey Miscellaneous Investigations Series Map 1-1375, scale 1:125,000.

Rezak, Richard, 1957, Stromatolites of the Belt Series in Glacier National Park and vicinity, Montana: U.S. Geological Survey Professional Paper 294-D, p. 127-154.

Whipple, J.W., compiler, 1992, Geologic map of Glacier National Park, Montana: U.S. Geological Survey Miscellaneous Investigations Series Map I-1508-F, scale 1:100,000.

Whipple, J.W., and Johnson, S.N., 1988, Stratigraphy and lithocorrelation of the Snowslip Formation (Middle Proterozoic Belt Supergroup), Glacier National Park, Montana: U.S. Geological Survey Bulletin 1833, 30 p.

U.S. Geological Survey Research, 1977, Large-scale gravitational spreading of mountain ridges in the Western part of the Cut Bank 1 x 2 quadrangle, northwestern Montana, Montana: U.S. Geological Survey Professional Paper 1050, p. 235.

Appendix A - List of digital files in the Cut Bank GIS (packaged as i2593.tar.Z)

--Uncompress the **i2593.tar.Z** file and extract the files from the resultant **i2593.tar** file.
--Use the **'importfile.aml**' in ArcInfo to IMPORT all of the *.E00 files for use in ArcInfo.
--Use the ArcInfo 'DRAW' command to plot the *.GRA file to your screen. (Make sure the display is set with the ArcInfo 'DISPLAY' command.)
--Use the ArcInfo 'HPGL2' command to create a HPGL2 file from the *.GRA file.
--Use the UNIX 'lpr -P<plotter_name> cb250k.hp' command to send the cb250k.hp file to a large-format color plotter that can interpret Hewlett-Packard Graphics Language.
--To re-create the *.GRA file, open the ArcPlot module, enter 'display 1040', enter a new file name for the graphics file, enter '&run cb250k' (and enter 'quit' to exit the ArcPlot module). See the 00readme.txt file for further file details.

Report text in portable document format:

- i2593.pdf

Primary ArcInfo interchange-format files (*.e00) and metadata (*.met) files for the digital geology:

- cb250k.e00
- cb250k.met

ArcInfo graphics (*.gra), HPGL2 (*.hp), encapsulated PostScript (*.eps), and portable document format (*.pdf) files for the geologic map sheet:

- cb250k.gra/.hp/.eps
- cb-map.pdf

Additional ArcInfo interchange -format files (*.e00) necessary to re-create the geologic map sheet:

- cb_quad.e00 - exterior boundary of the western part of the Cut Bank 1° x 2° quadrangle, northwestern Montana
- fnt026.e00 – font
- fnt037.e00 – font
- fnt038.e00 – font
- fnt039.e00 – font
- fnt040.e00 – font
- geoafa__.fon – font file
- geoafa__.pfb – font file
- geol_dia.lin.e00 - lineset
- wpgcmyk.shd.e00 – shadeset

AML, graphics, key, symbolset and text files necessary to re-create the geologic map sheet:

- scale2a.aml - plots scale bar on plate
- cb250k.aml - program that creates a graphics file of the geologic map
- indx_cb.gra - index map graphic
- usgslogo.gra – USGS logo
- cb-lin.key – lineset symbol values and descriptive text for lines
- cb-pol.key - shadeset symbol values and descriptive text for geologic map units
- geo.prj - a text file used to identify real-world (geographic) coordinates - for use in adding latitude and longitude notation around the margins of the map quadrangle
- tvm.prj - a text file to identify Transverse Mercator map projection - for use in adding latitude and longitude notation around the margins of the map quadrangle
- cal.dat – text file listing plotter calibration
- cb-crd.txt – text file listing map credits
- cb-dis.txt – text file with disclaimer statement
- cb-prj.txt –text file listing map projection information
- cb-ref.txt – text file listing map references

Appendix B - ArcInfo Macro Language program (cb250k.aml) used to plot the geologic map

```
/*cb250k.aml, 10/24/01, hzk
/*  to plot the digital geologic map of part of
the Cut Bank 1° x 2° quadrangle
/*  in color for USGS I-2593 (scale
1:250,000).
/*  MBMG provided digital ArcInfo files to
USGS SFO and then on to USGS
/*  SFO for the Headwaters project on
contract.
/**********************************
**********
/*  This ArcInfo Macro Language (AML)
program will plot the geologic map
/*   plate for the: Cut Bank 1° x 2°
quadrangle.
/*  To run this AML:
/*     1. Type '&run cb250k' at the 'Arc:'
prompt to start the program,
/*     2. Run the Arc/Info HPGL2 command
to convert the GRA file to an HPGL2
/*        file, for example,
/*        hpgl2 cb250k cb250k.hp # 1.0
opaque # 0 # # # cal.dat
/*     3. Execute the UNIX 'lpr' command
to print the 1:250,000-scale geologic
/*        map plot on your plotter, for
example,
/*        lpr -Ppicasso cb250k.hp
/*     4. To make an Encapsulated
PostScript file, at the ArcPlot prompt type:
/*        'display 1040 2' and enter
'cbcn250k' for a cb250k.eps file.
/**********************************
**********
ap
display 1040
cb250k.gra

clear
clearselect

pagesize 28.25 28.0
pageunits inches
mapunits meters
mapscale 250000
mapposition ll 0.75 6.0
mapangle 0.2

&set cover cb250k
&set quad cb_quad
&set key1 cb-pol.key
&set key2 cb-lin.key
&s credits cb-crd.txt
&s disclaimer cb-dis.txt
&s projection cb-prj.txt
&s reference cb-ref.txt
/* --> where 'cover' contains contacts and
rock units and 'quad'
/*       is the quadrangle boundary.

/*mape %cover%
mape %quad%
maplimits 0.0 2.4 26 26

/*draw outside box
linesymbol 9
linecolor 1
box 0.5 0.5 27.75 27.5
/*
textquality proportional
textfont 94021
linedelete all

/* cut marks
```

```
markerset plotter
markersymbol 1
markersize 0.1
marker 0 0
marker 0 28
marker 43.0 0
marker 43.0 28

&label credits
/*list credits
/*textfont 93713
textfont 94021
textquality proportional
textsize 0.12
move 16.25 6.7
textfile %credits%

&label disclaimer
textfont 93713
/*textfont 94021
textquality proportional
textsize 0.12
move 23.4 2.4
textfile %disclaimer%

&label proj
/*plot map projection notes
/*textfont 93713
textfont 94021
textquality proportional
textsize 0.12
move 1.8 6.9
textfile %projection%

&label references
/* list references
textfont 93711
textsize 0.25
textcolor 1
move 23.4 5.85
text 'References'
move 23.4 5.60
textsize 0.12
textquality proportional
textfont 94021
textfile %reference%

&label shadepolys
/* color polygons for geologic rock units
shadedelete all
shadeset wpgcmyk
polygonshade %cover% unit %cover%.ru

&label geocontacts
/* plot geologic_contacts and boundaries
linedelete all
lineset geol_dia.lin
res %cover% arcs linecode gt 0 and
linecode lt 40
arclines %cover% linecode %cover%.con
asel %cover% arcs
linedelete all
lineset geol_dia.lin
res %cover% arcs linecode gt 40 and
linecode lt 100
arclines %cover% linecode %cover%.con
asel %cover% arcs

&label structure
/* plot faults and folds with line patterns
linedelete all
lineset geol_dia.lin
res %cover% arcs linecode gt 100 and
linecode lt 600
arclines %cover% linecode %cover%.str
asel %cover% arcs

&label lgu
/* plot linear geologic units with line pattern
linedelete all
lineset geol_dia.lin
res %cover% arcs linecode gt 800
arclines %cover% linecode %cover%.lgu
asel %cover% arcs

&label mapquad
```

```
/* plot quadrangle boundary
linedelete all
lineset plotter
linesymbol 5
arcs %quad%

&label geolabels
textsize 0.10
res %cover% poly area gt 750000
textset geofont.txt
textsymbol 37
labeltext %cover% unit %cover%.ru cc
asel %cover% poly

&label titles
textfont 93715
textquality kern
textsize 0.35
plot usgslogo.gra box 2.0 25.75 5.0 26.75
move 5.5 26.5
text 'U.S. Department of the Interior'
move 5.5 25.9
text 'U.S. Geological Survey'
move  15.25 26.5
text ' Prepared in cooperation with the' lc
move 15.25 25.9
text 'Montana Bureau of Mines and
Geology' lc
move 27.5 26.5
text 'Geologic Investigations Series Map I-
2593' lr
move 27.5 25.9
text 'Database, version 1.0' lr
textfont 93711
textsize 0.4
move 10.3 5.3
text 'Spatial Digital Database of Selected
Data from the Geologic Map of the
Western' lc
move 10.3 4.6
text 'Part of the Cut Bank 1° x 2°
Quadrangle, Northwestern Montana' lc
textsize 0.3
move 10.3 4.1
text 'by Jack E. Harrison, James W.
Whipple, David J. Lidke, Helen Z. Kayser
and Robert J. Miller' lc
move 10.3 3.4
text '2002' lc
move 10.3 2.9
text '(map originally published in 1998)' lc

&label explan
/* plot explanation - geologic units
shadedelete all
shadeset wpgcmyk
textfont 93711
textsize 0.25
move 20.25 24.2
text 'List of Map Units'
textsize 0.12
textquality proportional
textfont 4555552
keyarea 20.25 6.5 38.0 23.7
keybox 0.6 0.35
keyseparation 0.2 0.2
keyshade %key1%

&label linekey
/*  plot explanation - line key
linedelete all
lineset geol_dia.lin
keybox 0.6 0.0
keyline %key2% nobox

&label scale
/* plot scale bars
linedelete all
lineset plotter
textfont 94021
textsize 0.12
&r scale2a 10.30 2.40 other 250000

&label index-map
plot indx_cb.gra box 23.4 3.0 26.4 5.0
textfont 93713
```

```
textquality proportional
textsize 0.12
move 23.4 2.85
text 'Index map showing map area

&label lat-long
/* plot neat line labels (latitude and
longitude)
mape %quad%
linecolor 1
mapprojection geo.prj tvm.prj
neatline -114 48.0 -112.50 49.0 geo.prj
neatlinehatch 0.25 0.25 0.2 0 geo.prj
textset geofont.txt
textsymbol 1
textsize 8 pt
textstyle typeset
textoffset -0.35 0.15
neatlinelabels 0.25 top all geo.prj dms
'%1%!pat1857; %2%!pat1727;
%3%!pat1728'
textoffset -0.75 0.0
neatlinelabels 0.25 left all geo.prj dms
'%1%!pat1857; %2%!pat1727;
%3%!pat1728'

&label done
quit
display 9999 3
draw cb250k
&return
```

Appendix C - Metadata file (cb250k.met) for the Cut Bank GIS

Identification_Information:
  Citation:
    Citation_Information:
      Originator:
        Harrison, J.E., Whipple, J.W., Lidke, D.J., Kayser, H.Z.,
        Miller, R.J.
      Publication_Date: 2002
Title:
  Edition 1.0
  Geospatial_Data_Presentation_Form vector digital data
  Series_Information Series_Name
  Publication_Information Publication_Place
  Online_Linkage http://geopubs.wr.usgs.gov/i-map/i2593/

Description:
  Abstract:
    The paper geologic map of the western part of the Cut Bank 1° x
    2° quadrangle, northwestern Montana (Harrison and others, 1998)
    was digitized and initially attributed by the Montana Bureau of
    Mines and Geology (MBMG) and remitted to the U.S. Geological
    Survey for further attribution and publication of the geospatial
    digital files. The resulting digital geologic map GIS can be
    queried in many ways to produce a variety of geological maps.
  Purpose:
    This digital geospatial database is one of many being created by
    the U.S. Geological Survey (USGS) as an ongoing effort to
    provide geologic information in a geographic information system
    (GIS) for use in spatial analysis.
  Supplemental_Information:
    This GIS dataset consists of one major ArcInfo dataset: a line
    and polygon file (cb250k) that contains geologic contacts and
    structures (lines) and geologic map rock units (polygons).

Time_Period_of_Content:
  Time_Period_Information:
    Single_Date/Time:
      Calendar_Date: 2002
  Currentness_Reference: publication date

Status:

Progress: Complete
Maintenance_and_Update_Frequency: None planned

Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -114.00
East_Bounding_Coordinate: -112.50
North_Bounding_Coordinate: 48.50
South_Bounding_Coordinate: 48.00

Keywords:
Theme:
Theme_Keyword_Thesaurus: none
Theme_Keyword: Geological Map
Theme_Keyword: Geology
Place:
Place_Keyword_Thesaurus: none
Place_Keyword: Flathead County
Place_Keyword: Glacier County
Place_Keyword: Lake County
Place_Keyword: Pondera County
Place_Keyword: Teton County
Place_Keyword: Montana
Place_Keyword: Pacific Northwest
Place_Keyword: USA

Access_Constraints: none

Use_Constraints:
This digital database is not meant to be used or displayed at any scale larger than 1:250,000 (e.g., 1:100,000, 1:24,000).

Any hardcopies utilizing these data sets shall clearly indicate their source. If the user has modified the data in any way, they are obligated to describe the types of modifications they have performed on the hardcopy map. User specifically agrees not to misrepresent these data sets, nor to imply that changes they made were approved by the U.S. Geological Survey.

Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Pamela D. Derkey

Contact_Organization: U.S. Geological Survey
Contact_Position: geologist
Contact_Address:
Address_Type: mailing and physical address
Address: 904 W. Riverside Ave., Rm. 202
City: Spokane
State_or_Province: Wa
Postal_Code: 99201
Country: USA
Contact_Voice_Telephone: 1-509-368-3114
Contact_Facsimile_Telephone: 1-509-368-3199
Contact_Electronic_Mail_Address: pderkey@usgs.gov

Data_Set_Credit:
The Harrison and others (1998) geological map was digitized and minimally attributed by Ken Sandau (Montana Bureau of Mines and Geology (MBMG)) who then provided four minimally attributed ArcInfo interchange-format files to the U.S.G.S.; Robert J. Miller (USGS) combined the faults coverage into the contact and rock unit coverage; and Helen Z. Kayser (contractor) attached and attributed an interim geologic map data model.

Native_Data_Set_Environment:
Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 1; ESRI ArcCatalog 8.1.1.649

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
Attribute accuracy was verified by manual comparison of the source with hard copy printouts and plots.

Logical_Consistency_Report:
Polygon and chain-node topology present. Polygons intersecting the neatline area closed along the border. Segments making up the outer and inner boundaries of a polygon tie end to end to completely enclose the area. Line segments are a set of sequentially numbered coordinate pairs. No duplicate features exist nor do duplicate points in a data string. Intersecting lines are separated into individual line segments at the point of intersection. All nodes are represented by a single coordinate pair which indicates the beginning or end of a line segment.

```
  Completeness_Report:
    This digital geologic map is wholly derived from Harrison and
    others (1998).
  Positional_Accuracy:
    Horizontal_Positional_Accuracy:
      Horizontal_Positional_Accuracy_Report: +/- 127 meters

Spatial_Reference_Information:
  Horizontal_Coordinate_System_Definition:
    Planar:
      Map_Projection:
        Map_Projection_Name: Transverse Mercator
        Transverse_Mercator:
          Scale_Factor_at_Central_Meridian: 1.000000
          Longitude_of_Central_Meridian: -113.000000
          Latitude_of_Projection_Origin: 0.000000
          False_Easting: 0.000000
          False_Northing: 0.000000
      Planar_Coordinate_Information:
        Planar_Coordinate_Encoding_Method: coordinate pair
        Coordinate_Representation:
          Abscissa_Resolution: 0.000795
          Ordinate_Resolution: 0.000795
        Planar_Distance_Units: meters
    Geodetic_Model:
      Horizontal_Datum_Name: D_Clarke_1866
      Ellipsoid_Name: Clarke 1866
      Semi-major_Axis: 6378206.400000
      Denominator_of_Flattening_Ratio: 294.978698
Entity_and_Attribute_Information:
  Overview_Description:
    Entity_and_Attribute_Overview:
      The 'Spatial digital database of selected data from the geologic
      map of the western part of the Cut Bank 1 x 2 degree quadrangle,
      ...' contains a detailed description of each attribute
      code. The database includes a geologic linework arc attribute
      table, cb250k.aat, that relates to the cb250k.con (contact
      look-up table), cb250k.st2 (structure look-up table),and
      cb250k.ref (source reference look-up table) files; a rock unit
      polygon attribute table, cb250k.pat, that relates to the
      cb250k.ru (rock unit look-up table) and cb250k.ref (source
      reference look-up table) files.
```

Entity_and_Attribute_Detail_Citation:
A detailed description of the items in the western part of the Cut Bank 250K database are given in the report text provided, available in Adobe Acrobat PDF format on the World Wide Web at: http://geopubs.wr.usgs.gov/i-map/i2593/

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Organization: U.S. Geological Survey
Contact_Instructions:
This report is only available in the electronic format at URL = http://geopubs.wr.usgs.gov /i-map/i2593/ or via anonymous FTP from geopubs.wr.usgs.gov, in the directory pub/i-map/i2593.
Distribution_Liability:
The U.S. Geological Survey (USGS) provides these geographic data "as is".The USGS makes no guarantee or warranty concerning the accuracy of information contained in the geographic data. The USGS further make no warranties, either expressed or implied as to any other matter whatsoever, including, without limitation, the condition of the product, or its fitness for any particular purpose. The burden for determined fitness for use lies entirely with the user. Although these data have been processed successfully on computers at the USGS, no warranty, expressed or implied, is made by the USGS regarding the use of these data on any other system, nor does the fact of distribution constitute or imply any such warranty.

In no event shall the USGS have any liability whatsoever for payment of any consequential, incidental, indirect, special, or tort damages of any kind, including, but not limited to, any loss of profits arising out of the delivery, installation, operation, or support by the USGS.

This digital geologic map database of the western part of the Cut Bank 1° x 2° quadrangle is not meant to be used or displayed at any scale larger than 1:250,000 (e.g., 1:100,000 or 1:24,000).

Standard_Order_Process:

```
    Digital_Form:
      Digital_Transfer_Information:
        Format_Name: ARC
        File_Decompression_Technique:
          Unix compress files.  Use Unix
          uncompress, Winzip or equivalent.
      Transfer_Size: 3.771
      Digital_Transfer_Option:
        Online_Option:
          Computer_Contact_Information:
            Network_Address:
              Network_Resource_Name: USGS website
          Access_Instructions: http://geopubs.wr.usgs.gov/i-map/i2593

Metadata_Reference_Information:
  Metadata_Date: 20020213
  Metadata_Contact:
    Contact_Information:
      Contact_Organization_Primary:
        Contact_Organization: U.S. Geological Survey
        Contact_Person: Pamela D. Derkey
      Contact_Position: Geologist
      Contact_Address:
        Address_Type: 904 W. Riverside Ave., Room 202
        City: Spokane
        State_or_Province: Washington
        Postal_Code: 99201
      Contact_Voice_Telephone: 1-509-368-3114
      Contact_Facsimile_Telephone: 1-509-368-3199
      Contact_Electronic_Mail_Address: pderkey@usgs.gov
  Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
  Metadata_Standard_Version: FGDC-STD-001-1998
  Metadata_Time_Convention: local time
  Metadata_Access_Constraints: none
  Metadata_Use_Constraints: none
  Metadata_Extensions:
    Online_Linkage: http://www.esri.com/metadata/esriprof80.html
    Profile_Name: ESRI Metadata Profile
```